



ATC Surveillance

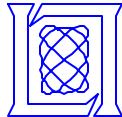
A Retrospective Look

Raymond R. LaFrey
Air Traffic Control Program Manager

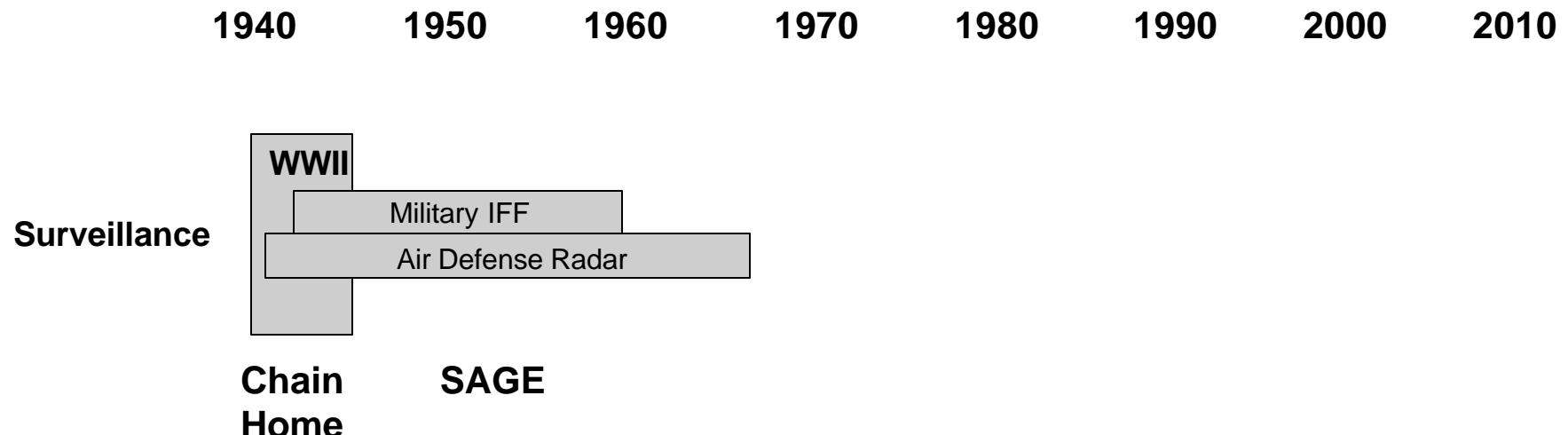


Outline

- **The History**
 - Radar Origins
 - The Last 30 Years
- Some Observations
- Looking Ahead



Historical Perspective





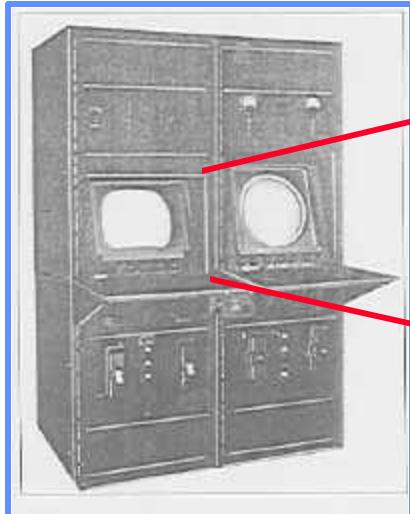
WW II British Chain Home Radar

“The Radio
Detection
Of Aircraft”
1935 Report

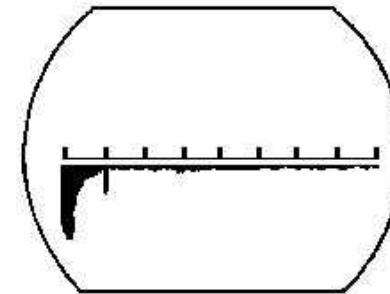
Watson-Watt



1939 First Chain Home
Radar Station

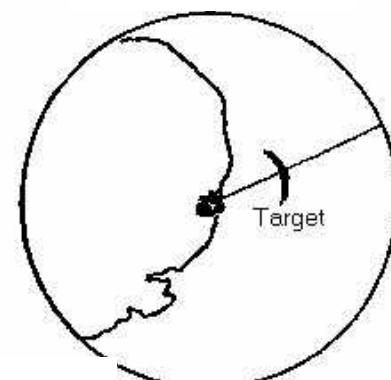


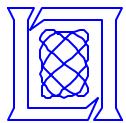
200 Mile RHI



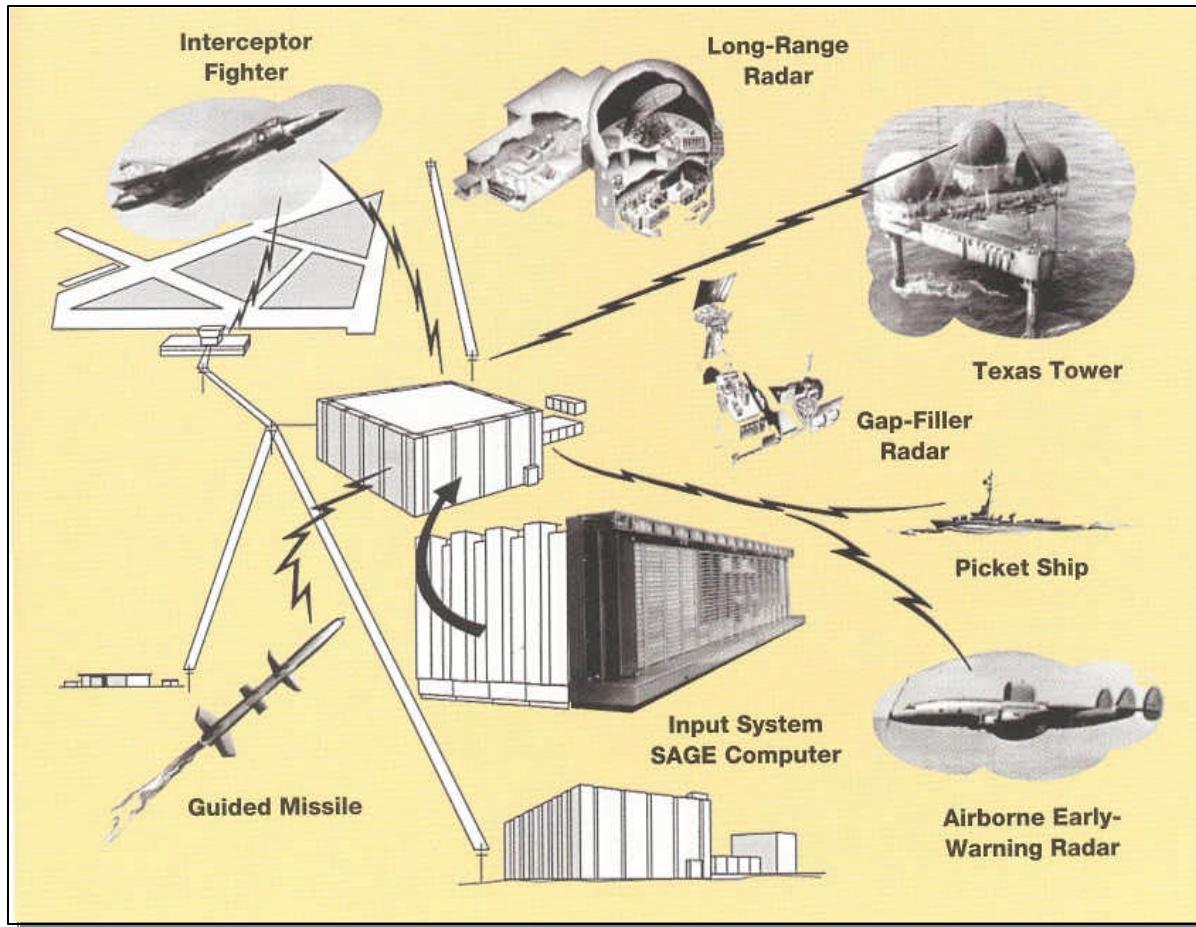
25 Mile Target

60 Mile PPI





The SAGE (Semi-Automatic Ground Environment) Air Defense System



R&D 1951 - 1957

Enabling Technologies

Modems

Core Memory

Real Time Computing

Key Engineers

Jay Forrester

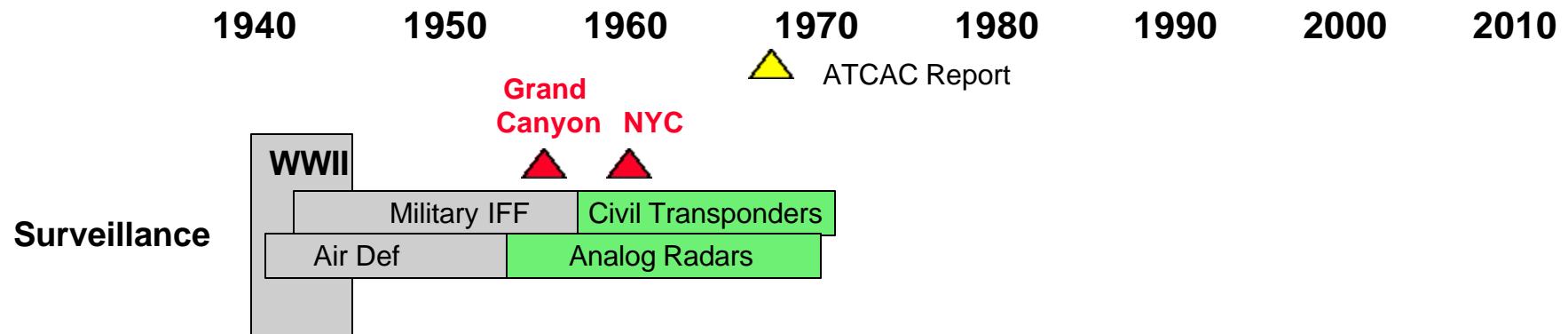
Bob Everett

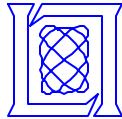
Norman Taylor

Herb Bennington

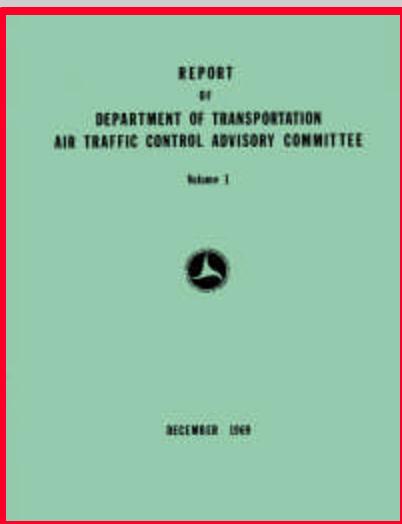


Historical Perspective

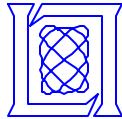




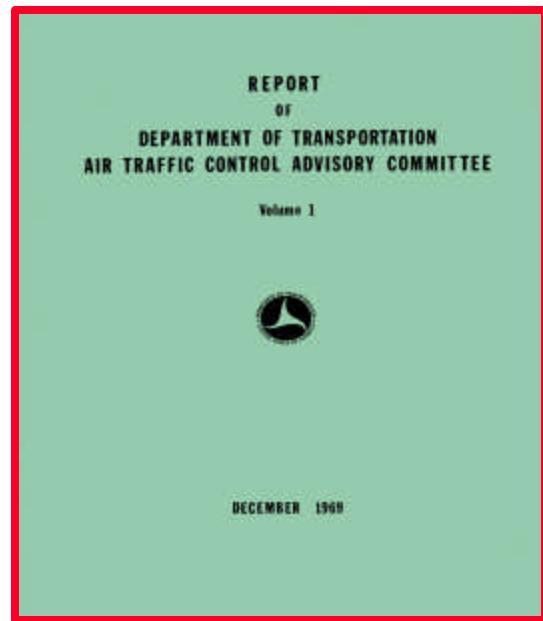
“Air traffic is in crisis. The crisis ... is the direct result of the failure of airports and air traffic control to keep up with the growth of the aviation industry.”



**DoT Air Traffic Control
Advisory Committee
December 1969**



ATCAC Recommendations

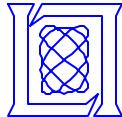


Improve secondary radar

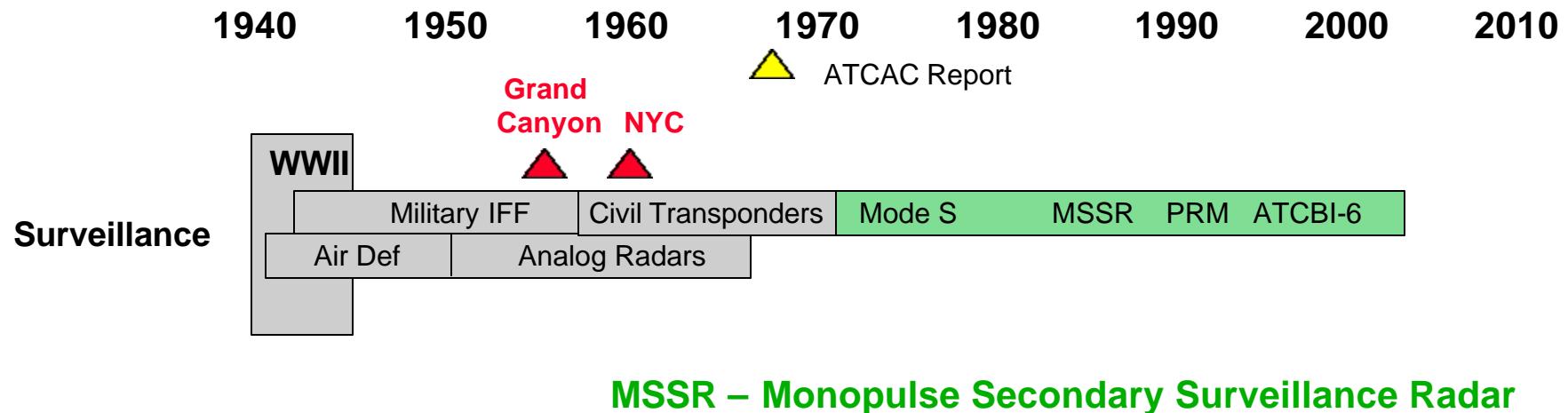
**Discrete Addressing
Integral data link**

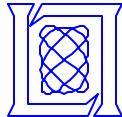
**Develop Scanning Beam ILS
aka MLS**

**Develop automated separation
assurance**



Historical Perspective





Mode S Sensor

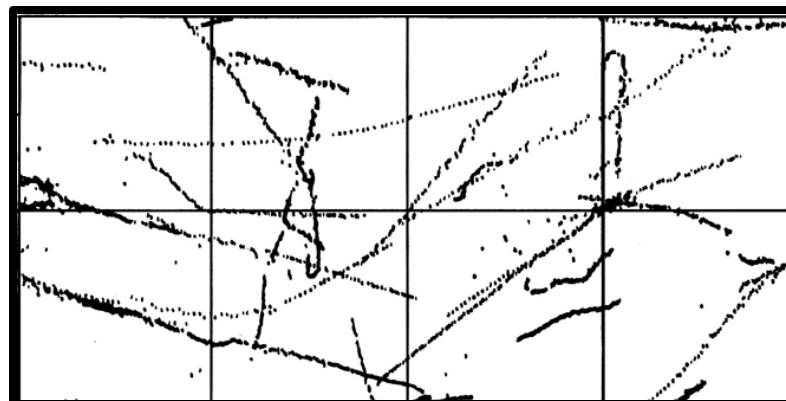


Mode S / ASR- 9 Antenna

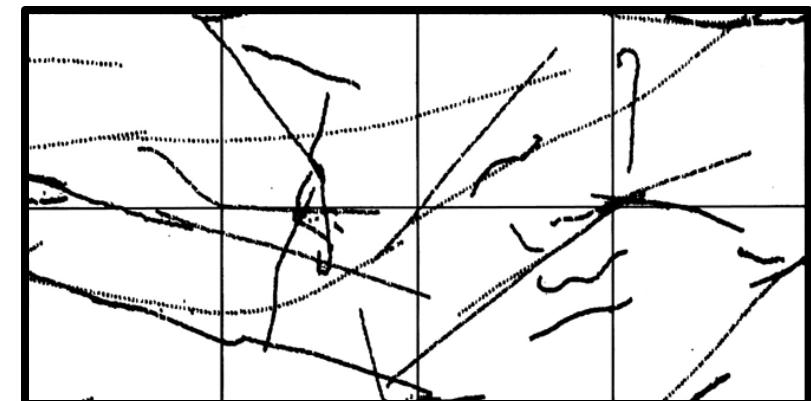
Monopulse Azimuth Estimation
1 mrad RMS ~ 50:1 beam split
Vertical Antenna Aperture

Advanced Sweep and Scan Processing
>90% Pd with low Pfa
High code reliability

U.S.: Westinghouse and Unisys
Europe: Cossor (UK) built MSSRs



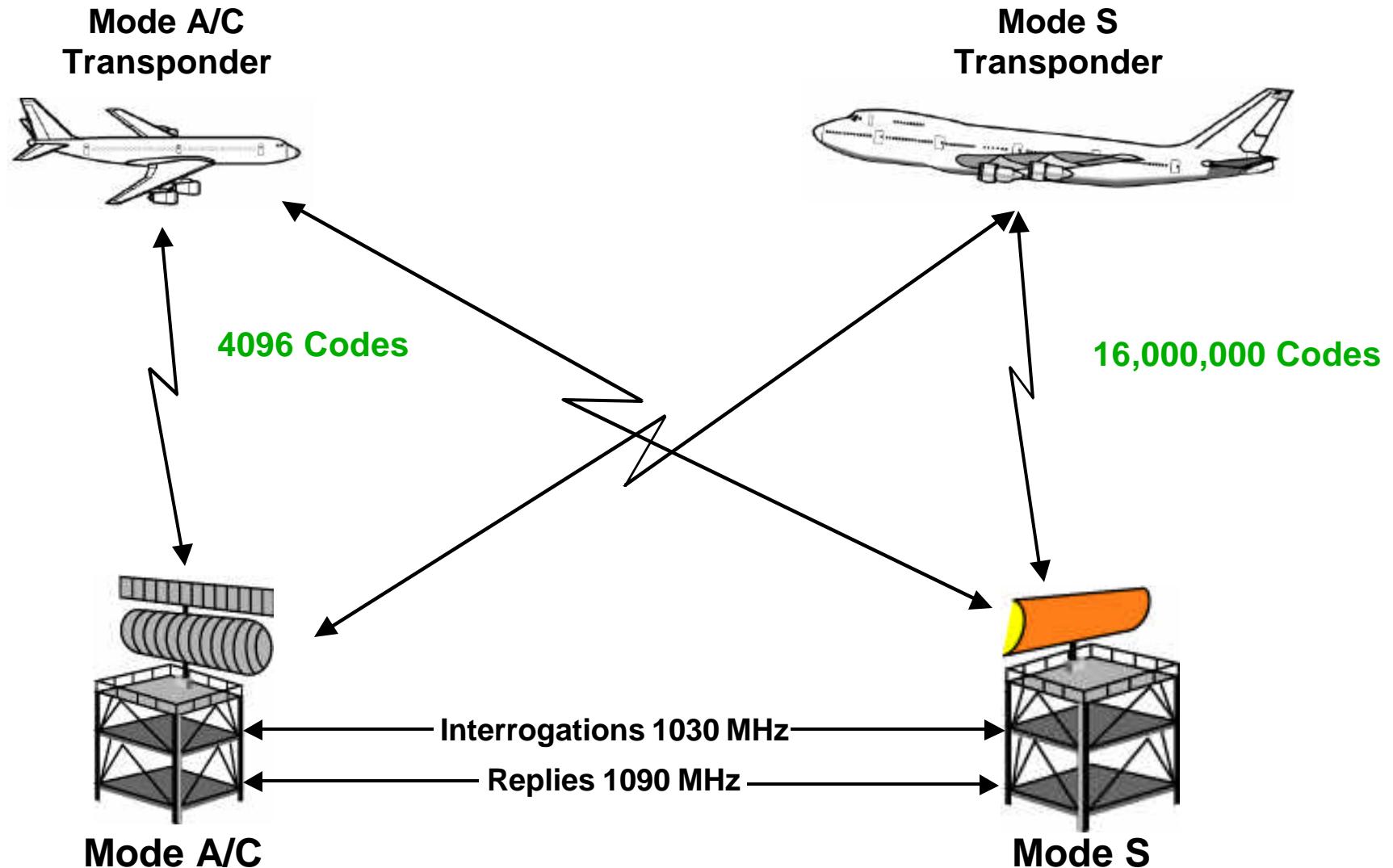
Legacy Target Reports

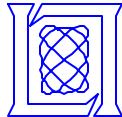


Monopulse SSR Target Reports

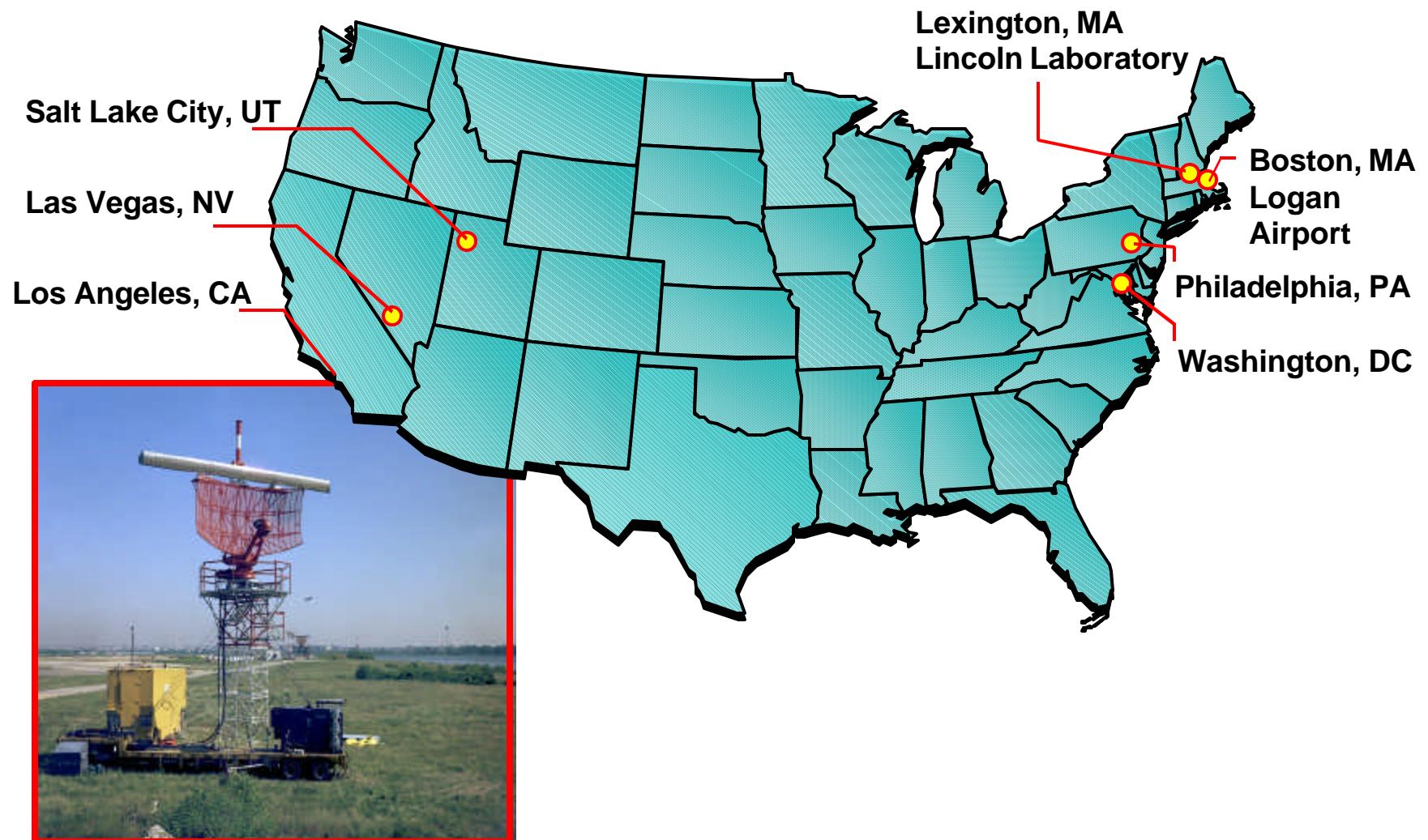


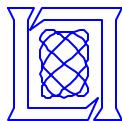
A Key Requirement: Compatibility with Legacy Technology



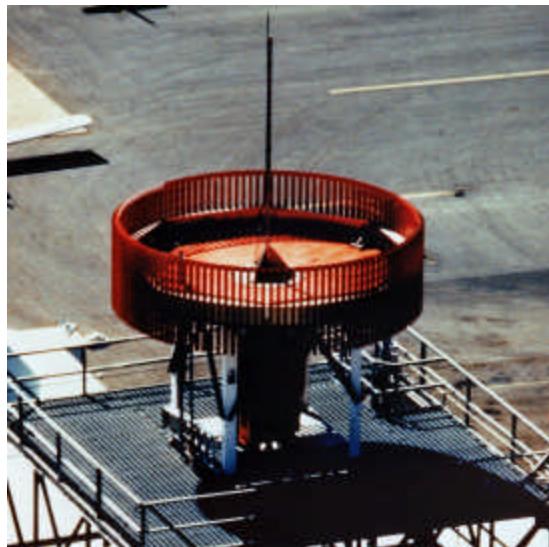


Mode S / MSSR Field Evaluations





Parallel Approach Monitors



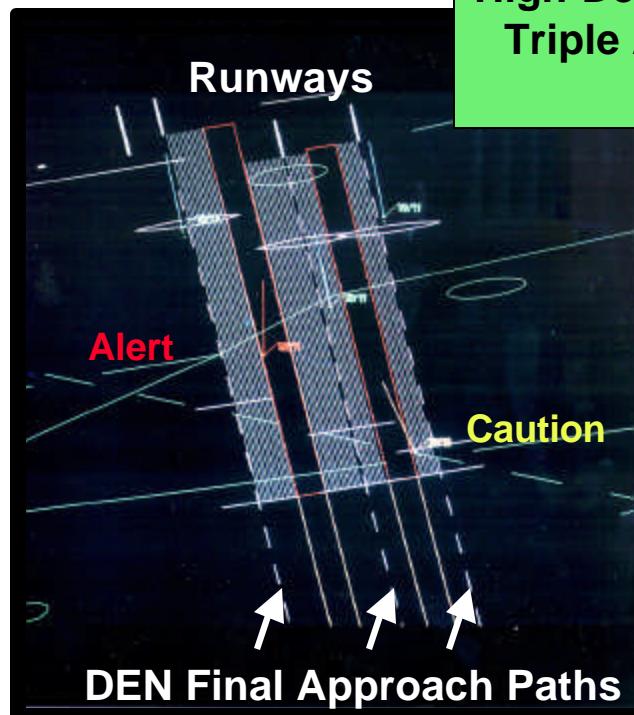
E-Scan - Allied Signal

Precision Runway Monitor

Authorized Separation

- 3400 Feet Straight In
- 3000 Feet Offset Localizer

MSP,STL,JFK,ATL,PHL,CLT

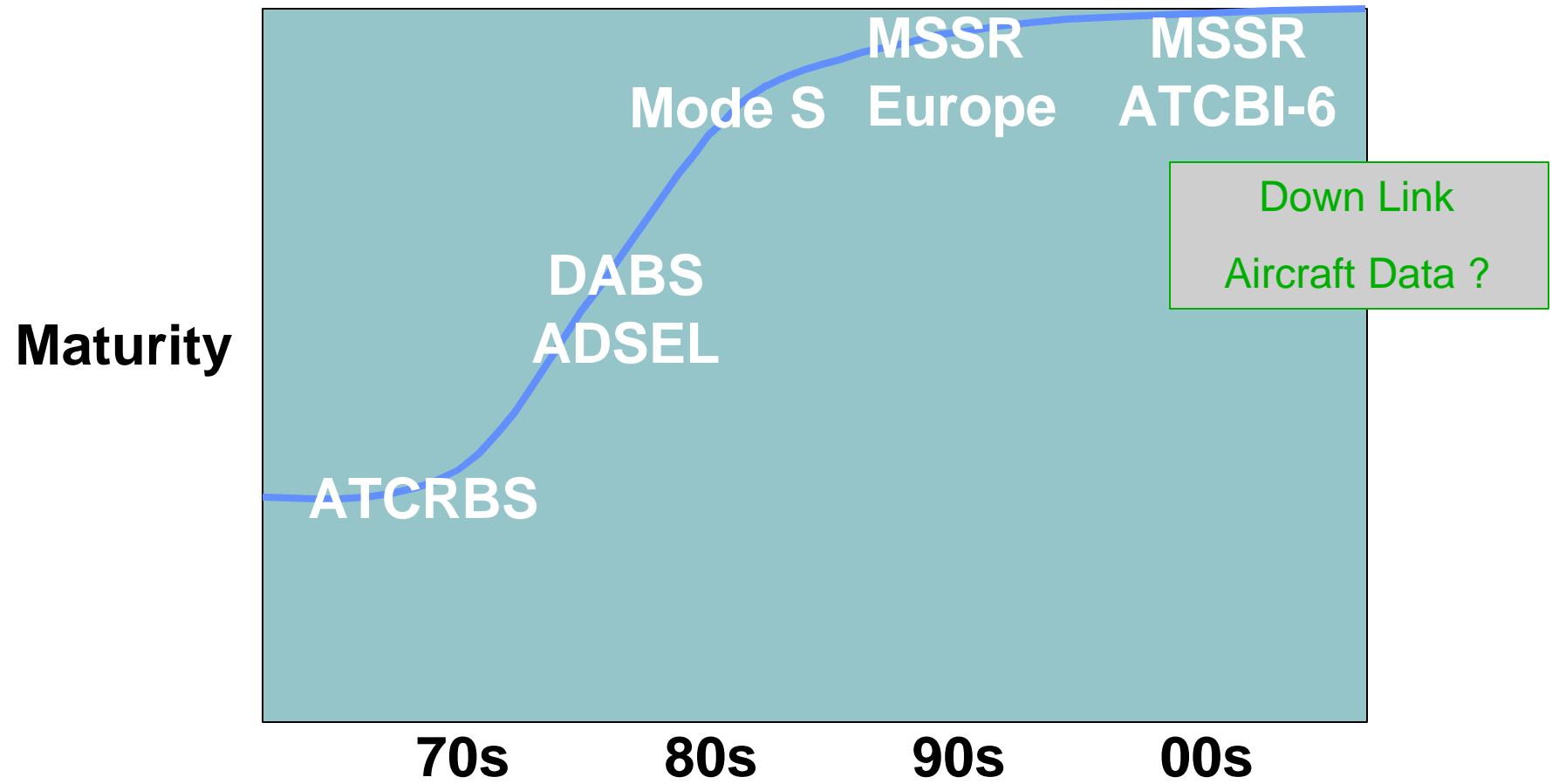


Final Monitor Aide
High Density Altitude
Triple Approaches
DEN



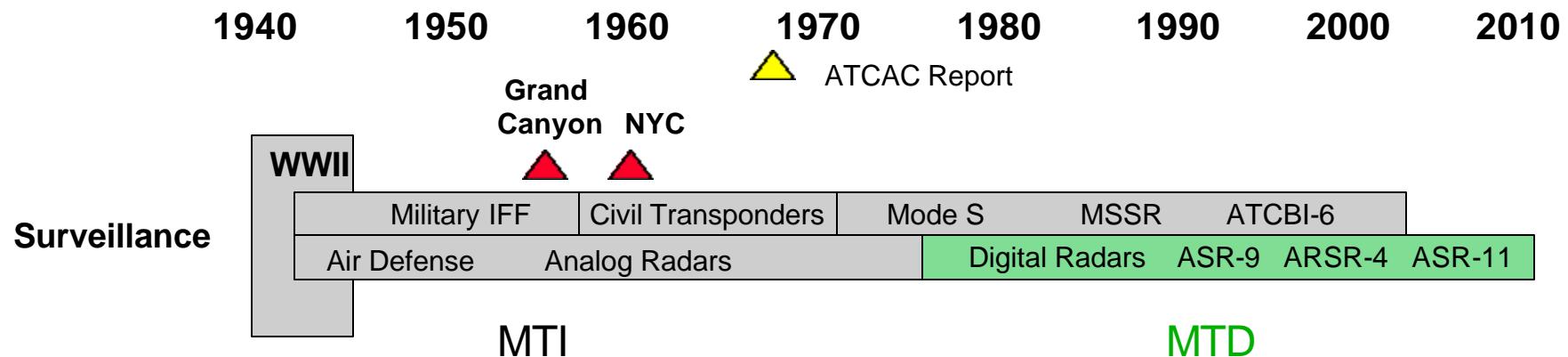


Secondary Surveillance Radar Maturity





Historical Perspective



MTI Moving Target Indicator
2 or 3 Pulse Ground Clutter Cancellation

MTD Moving Target Detector
8 to 10 Doppler filters
Distinguish aircraft from ground clutter and weather

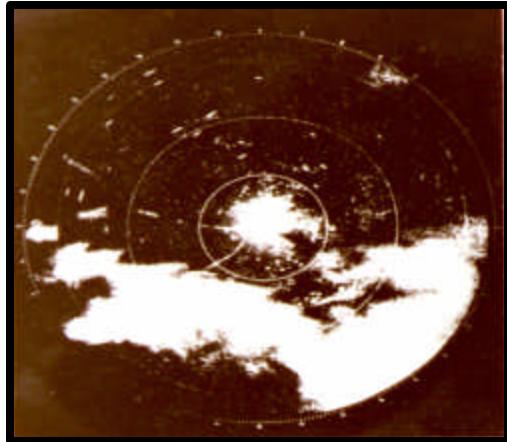


MTD Airport Surveillance Radar ASR-9



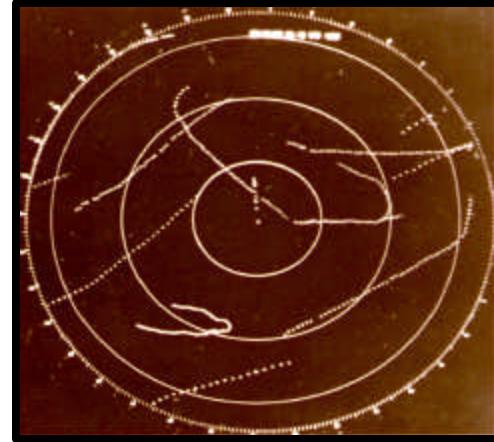
- First Moving Target Detector Radar
 > 50 dB Sub Clutter Visibility
- Established Radar Architecture for FAA and DoD
- Produced by Westinghouse

Raw Video



5 Mile Range Rings

MTD



Burlington, Vt. Tests

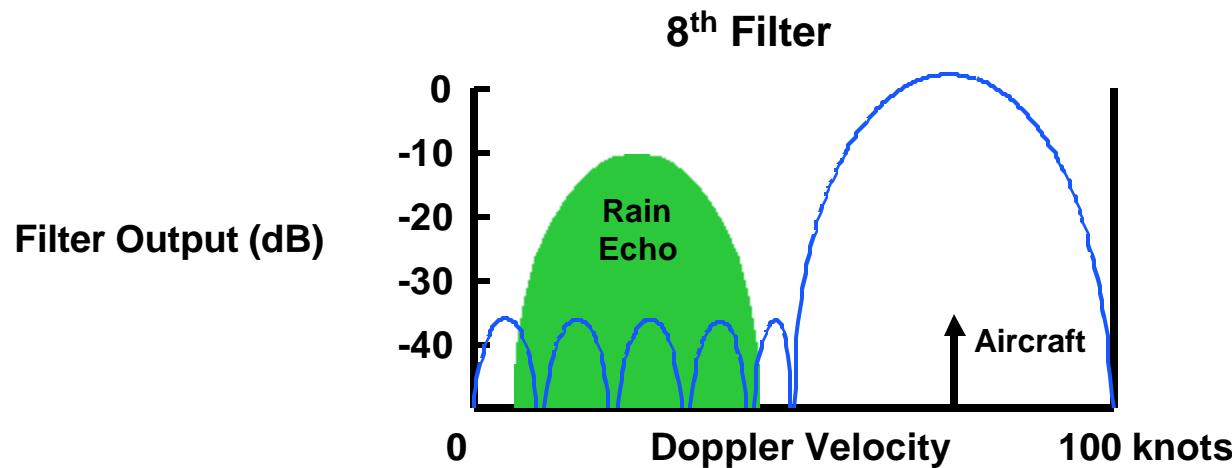


MIT Lincoln Laboratory



MTD Doppler Filtering

- Low Doppler side lobes for rain rejection
- Doppler selectivity to reject moving clutter (e.g. birds, ground traffic)

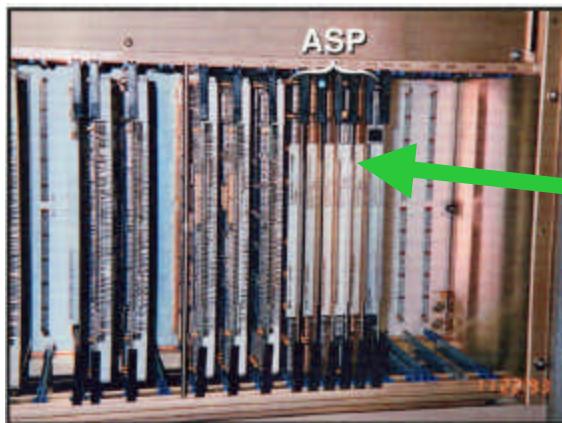




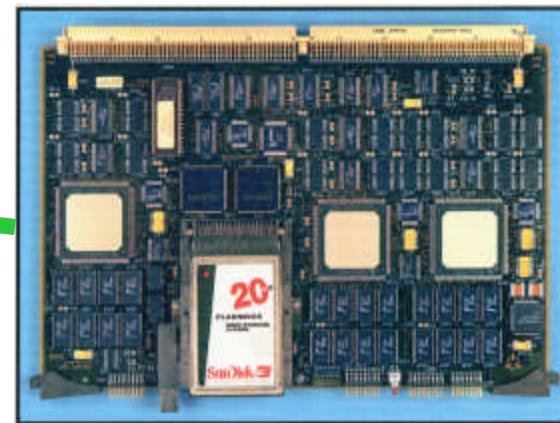
1990s ASR-9 Upgrade



Original Processor



Upgrade Processor

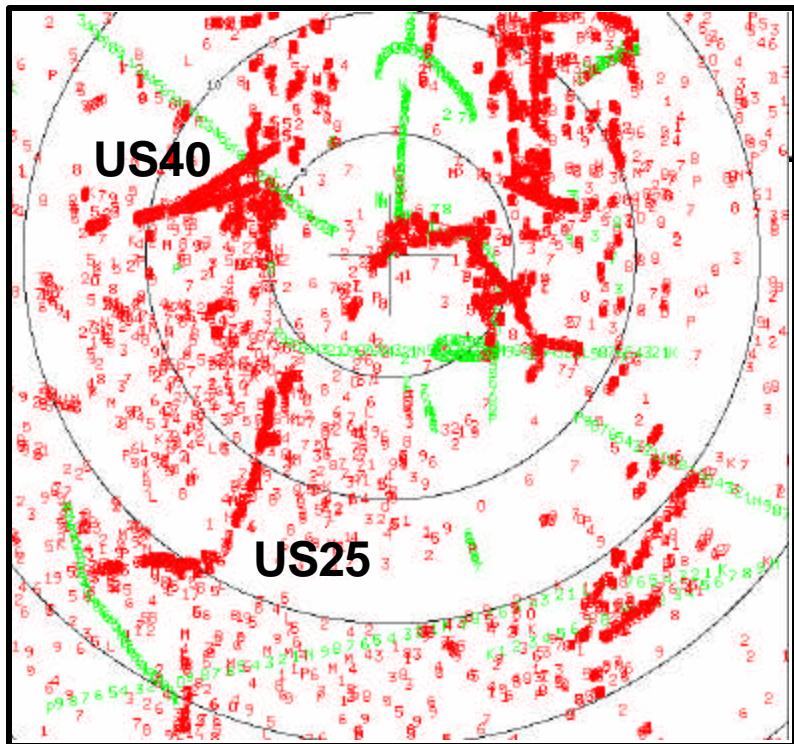


MIT Lincoln Laboratory

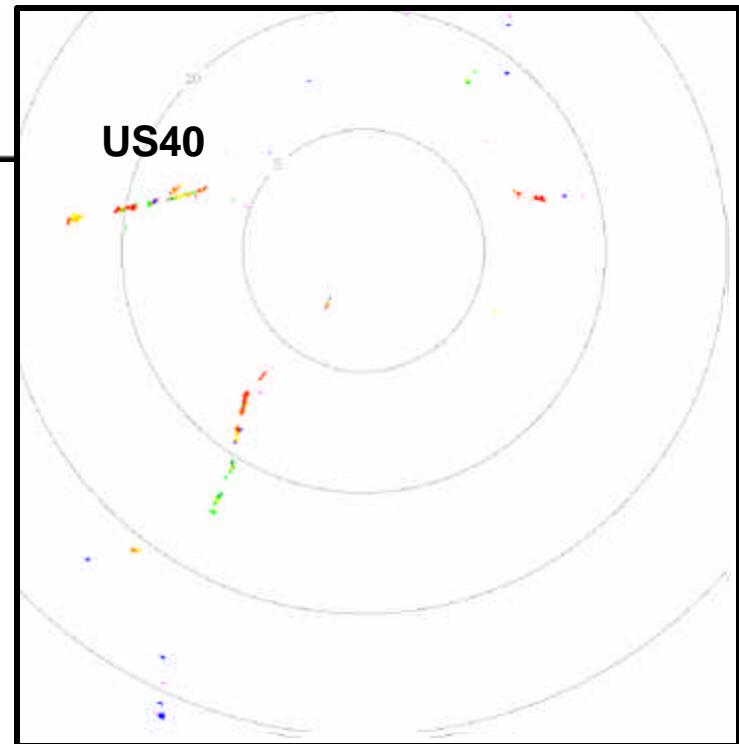


Adaptive Censoring of Ground Clutter and Road Traffic

Albuquerque, 15 July 1999



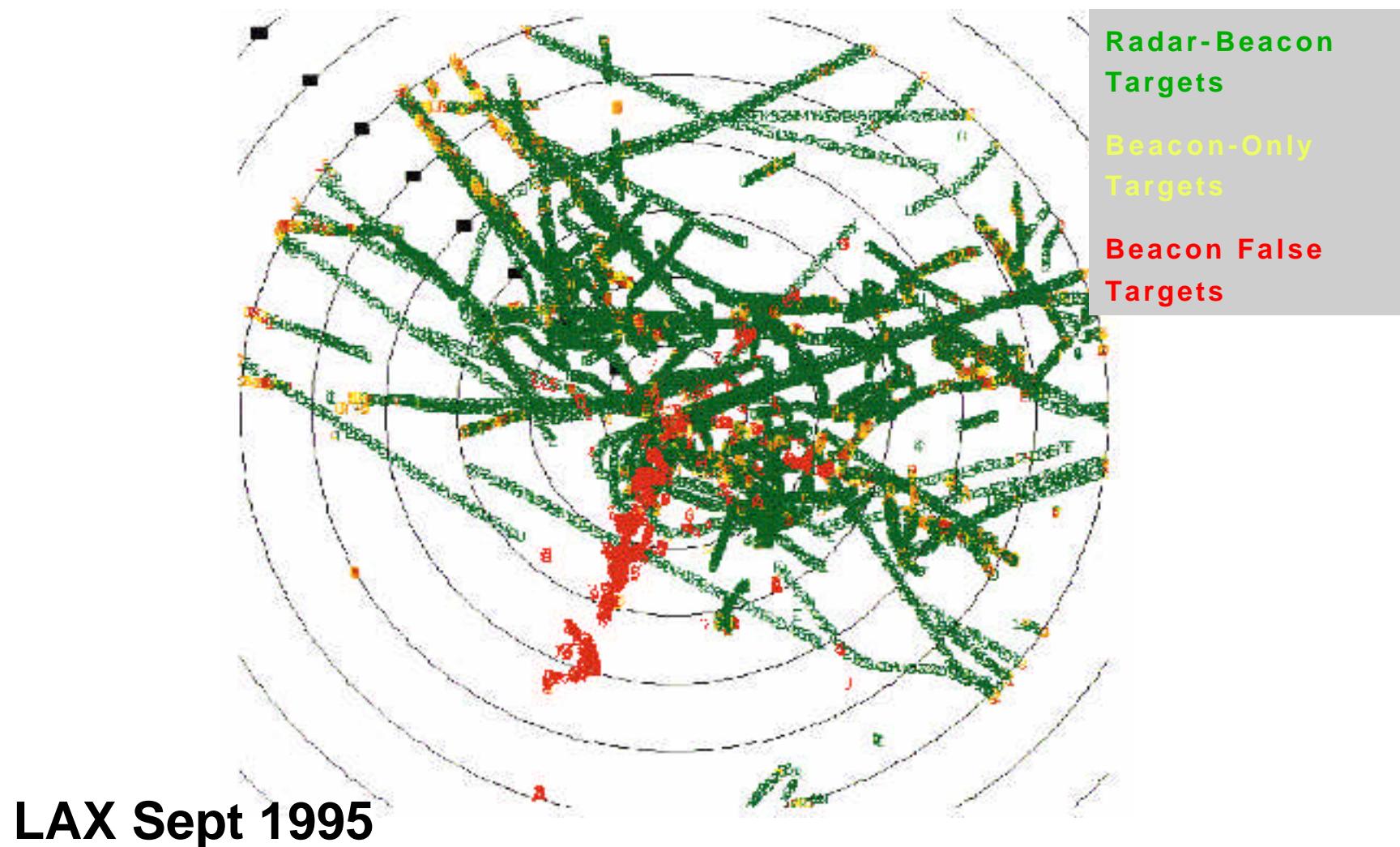
Real Aircraft
Rejected False Signals



Geo censor Map
(1 of 8 Doppler Filters)

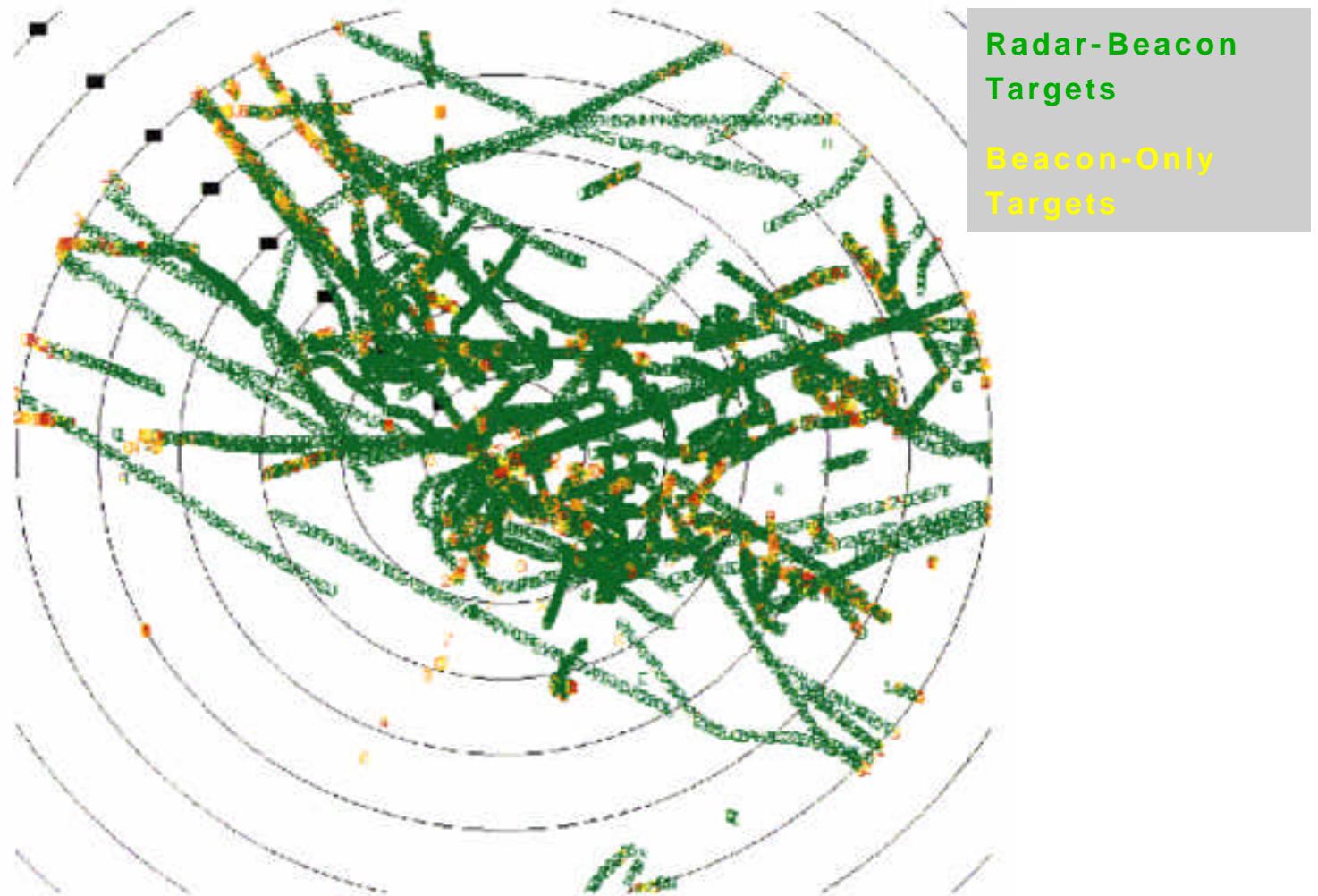


Beacon False Target Removal





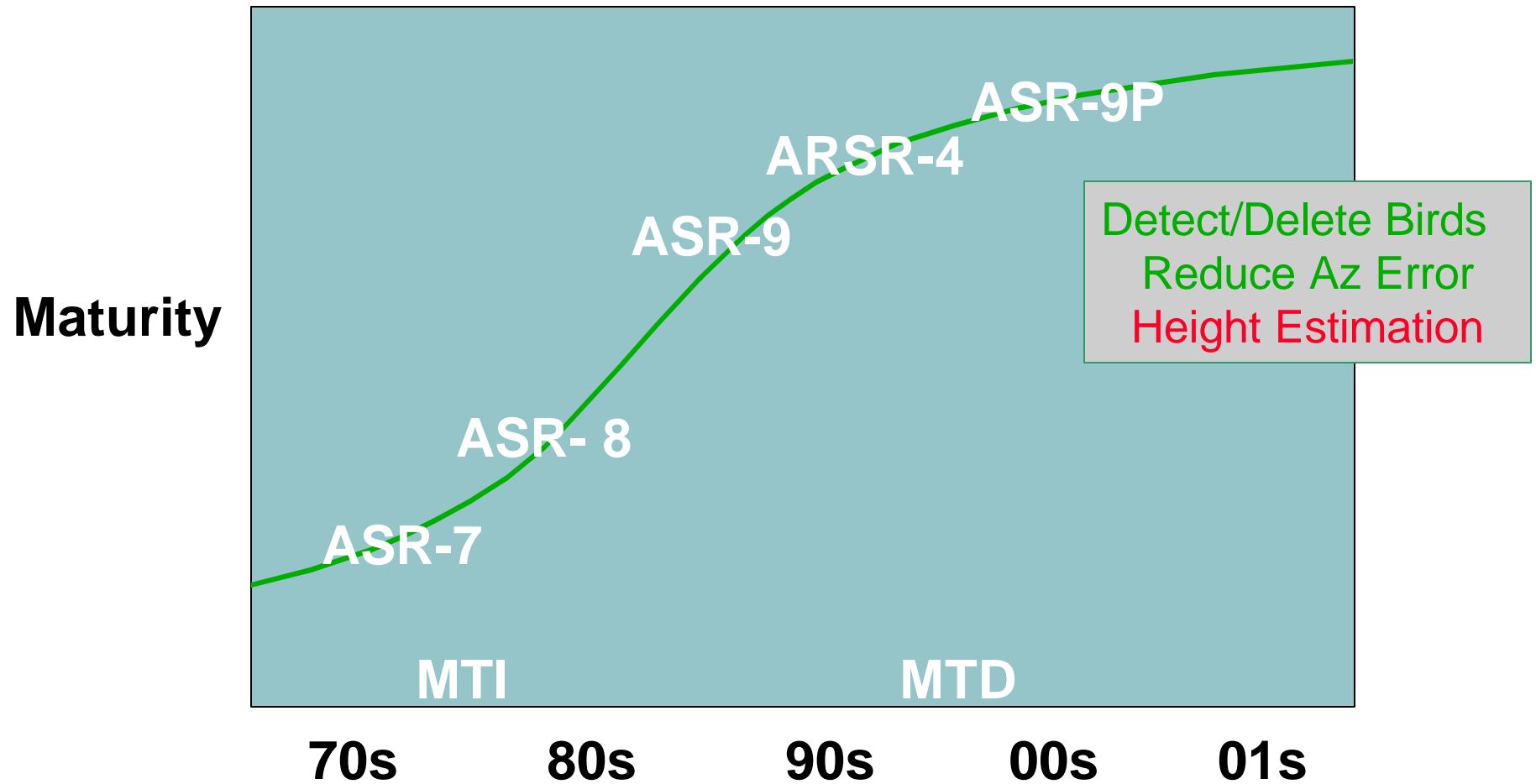
Beacon False Target Removal



LAX Sept 1995

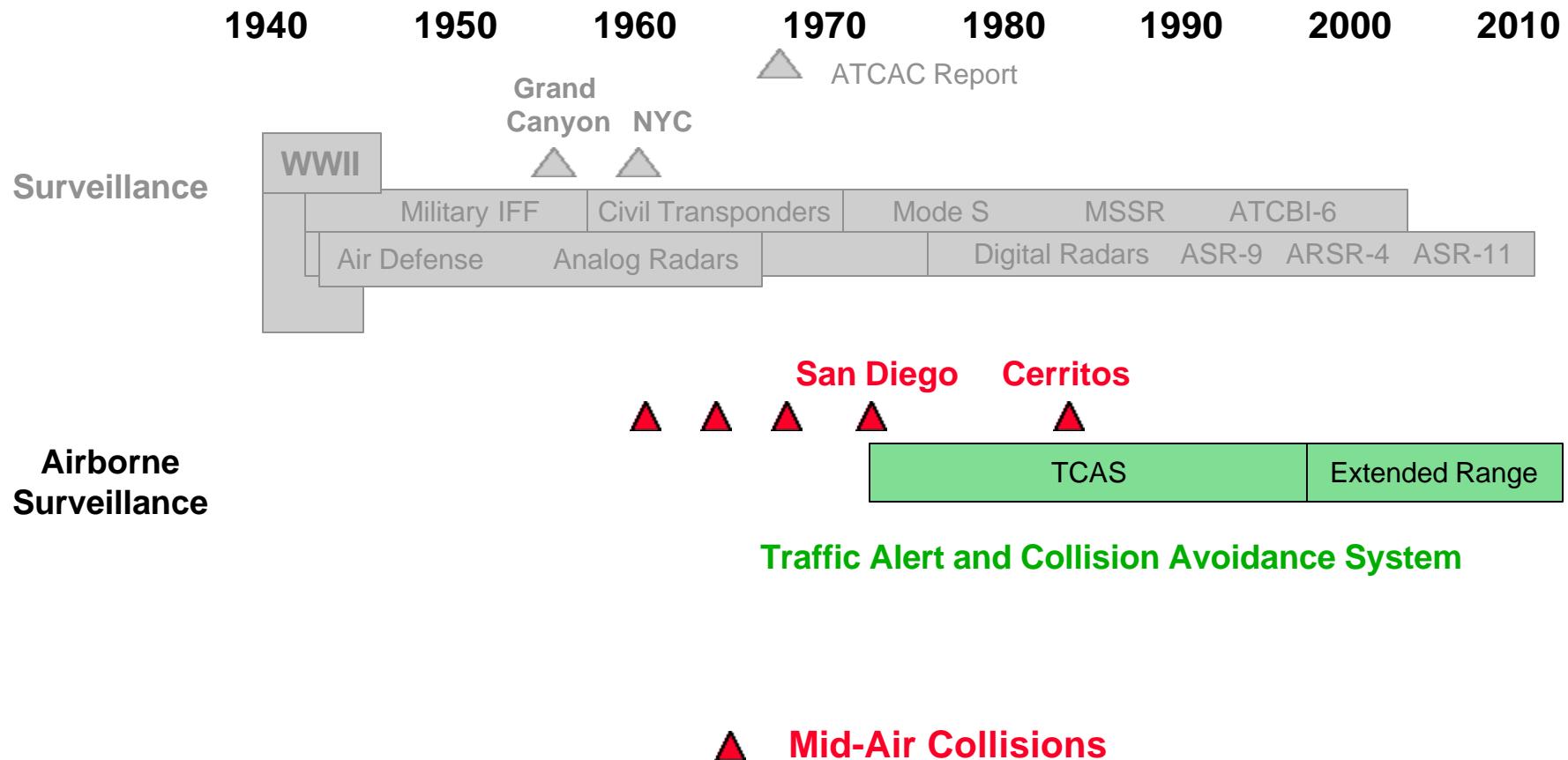


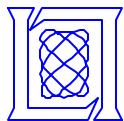
Primary Surveillance Radar Maturity



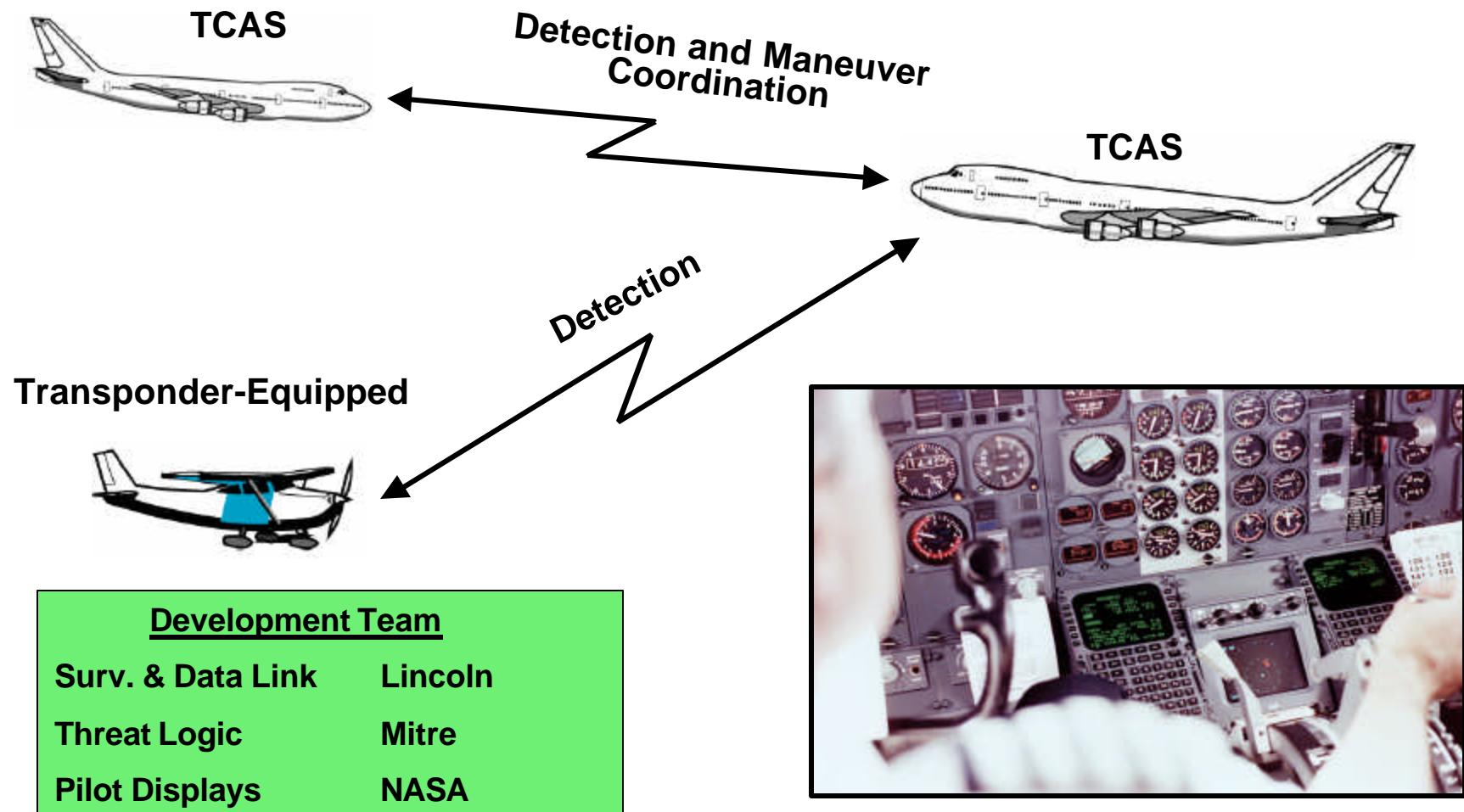


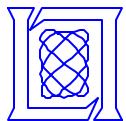
Historical Perspective





Traffic Alert and Collision Avoidance System





TCAS Surveillance Development

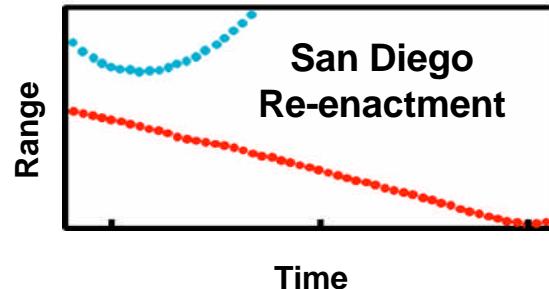
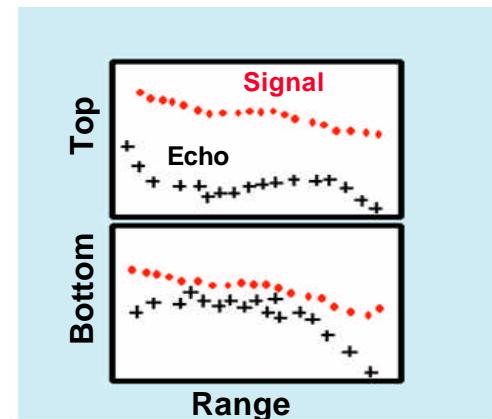
Airborne Measurements



Air-Air Coordination



Multipath Effects

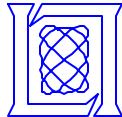


Operational Trials

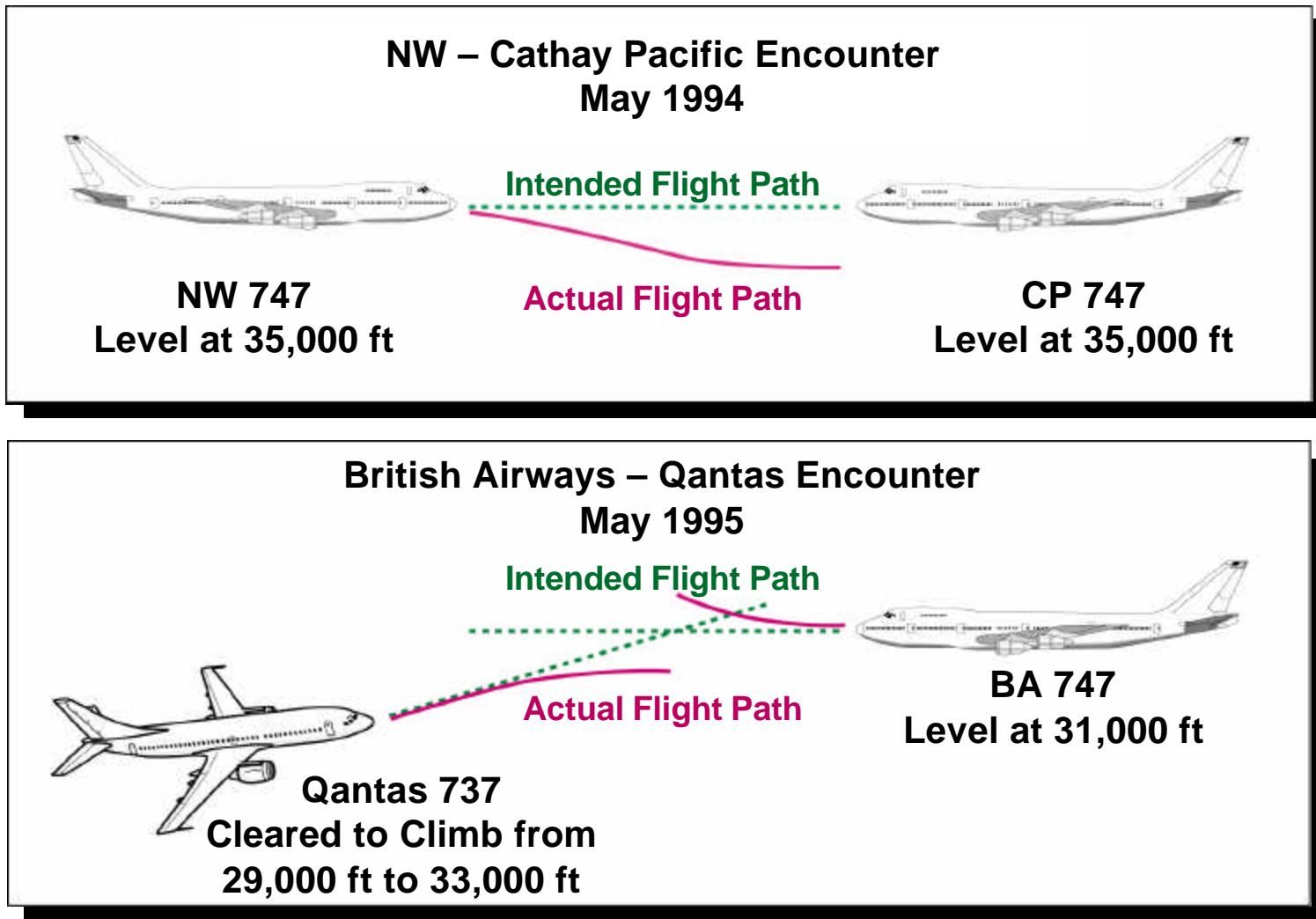


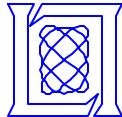
Production Avionics Allied Signal, Collins, Honeywell



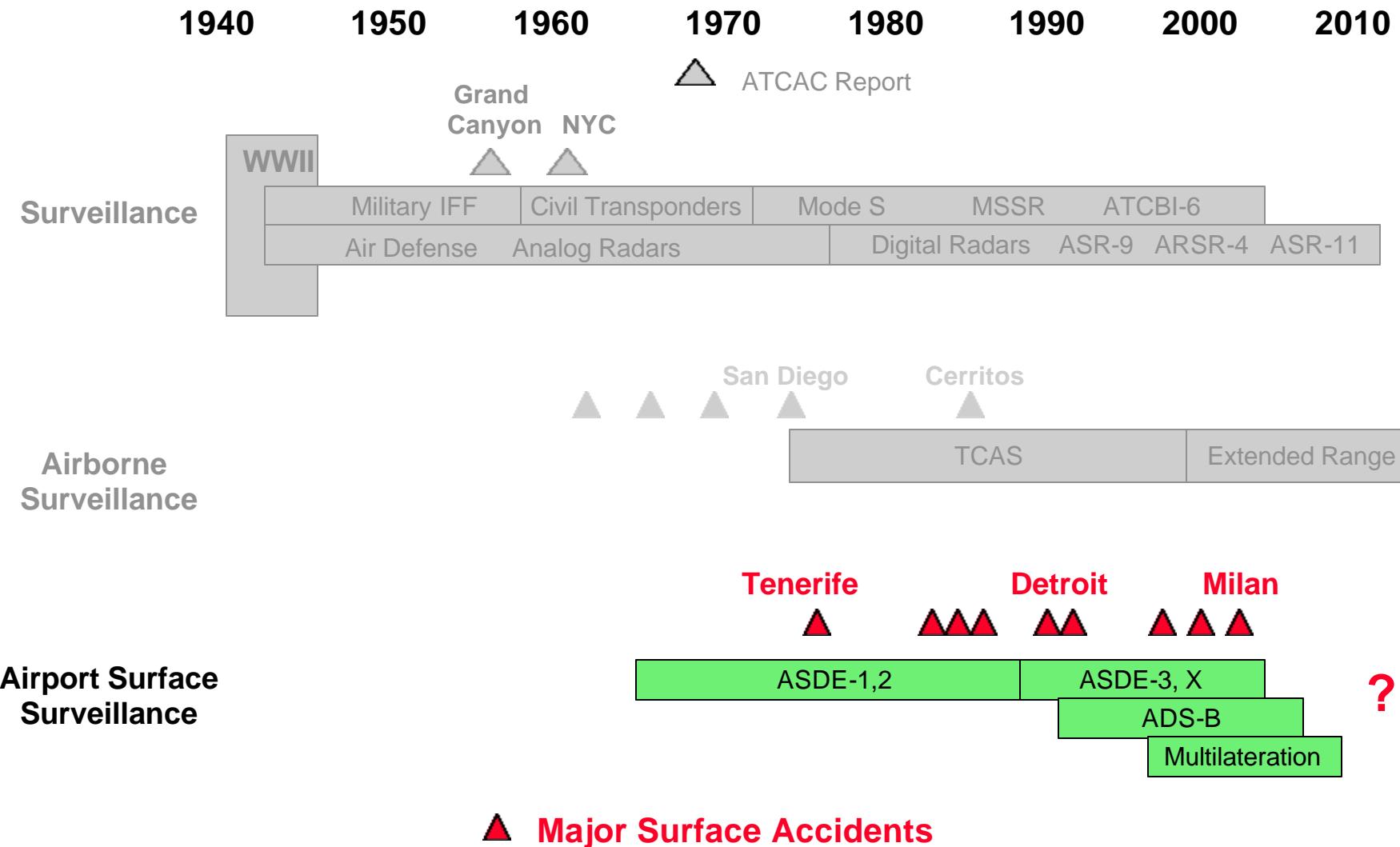


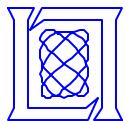
TCAS “Saves”



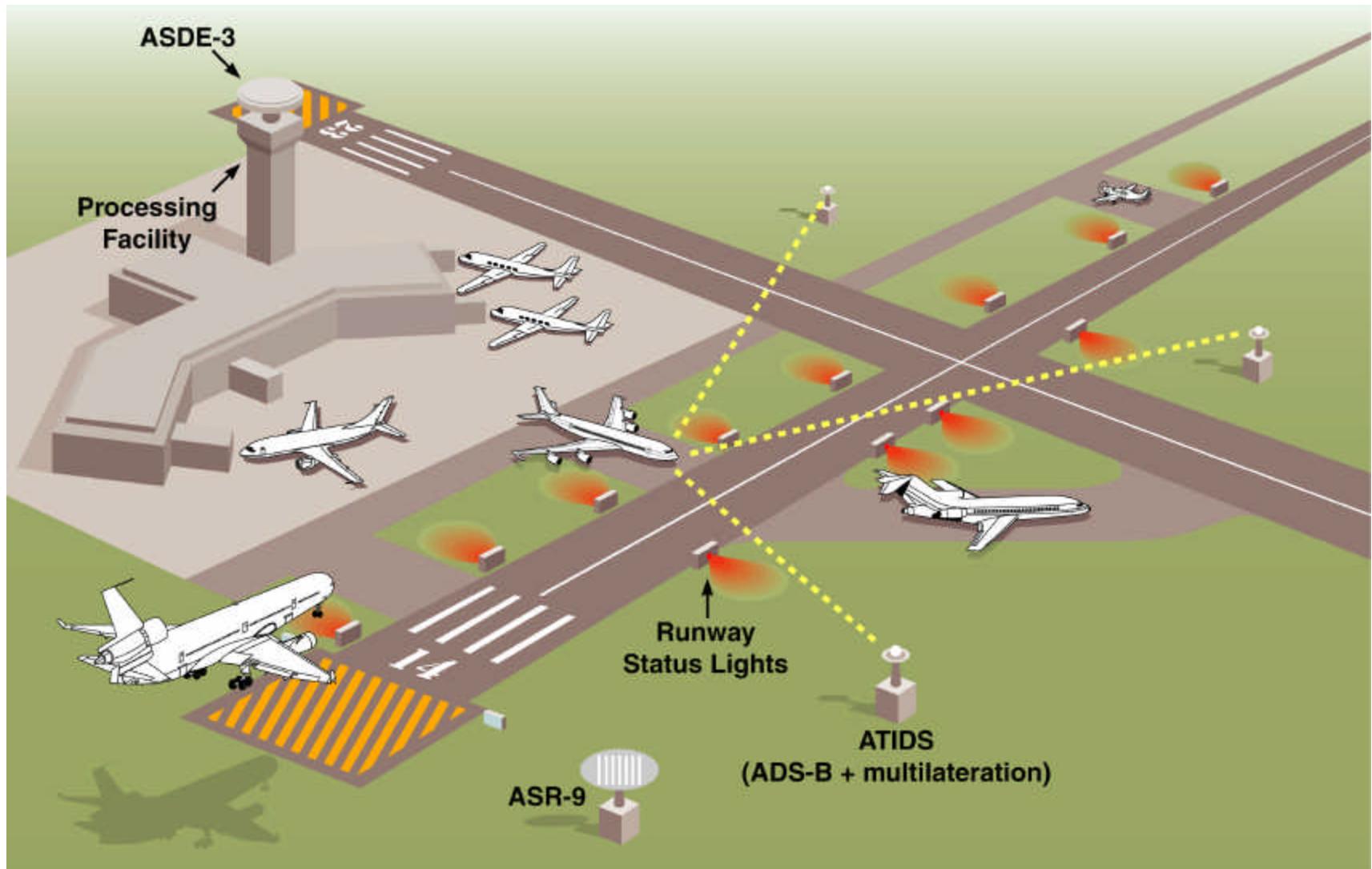


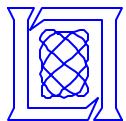
Historical Perspective



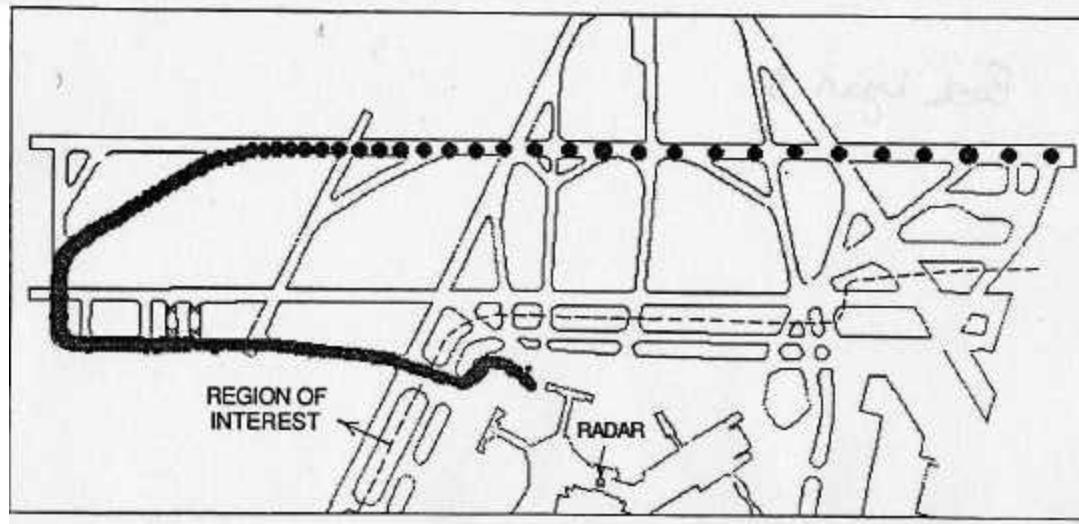
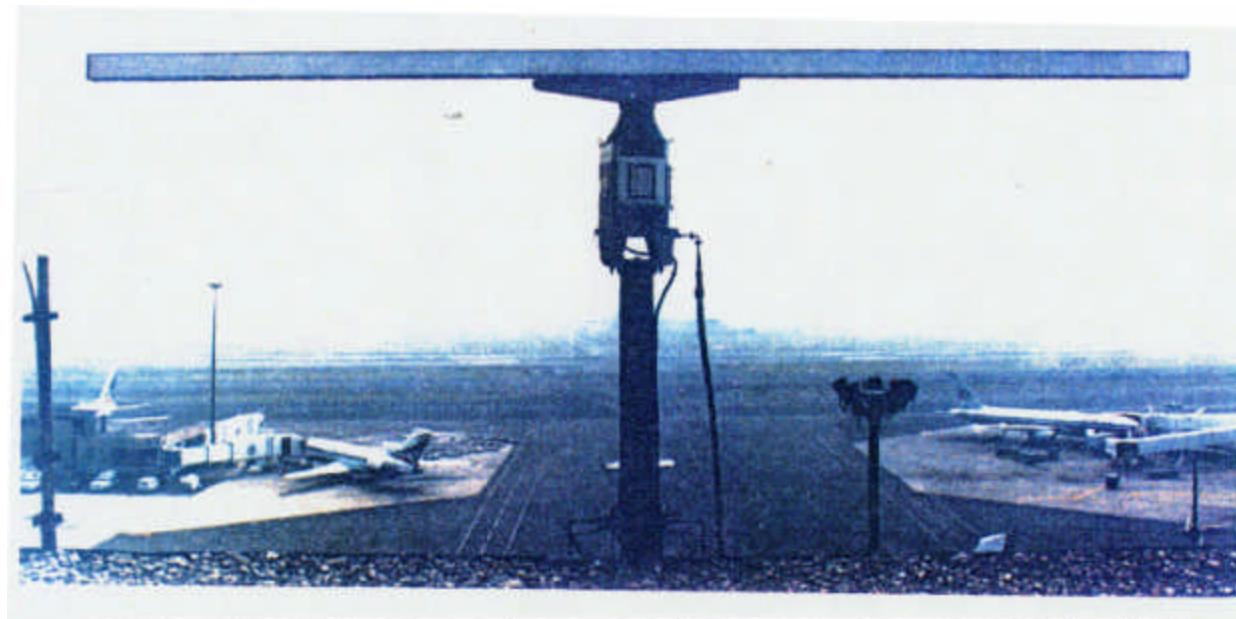


Airport Surface Surveillance Notion



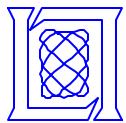


X-Band Marine Radar at Logan

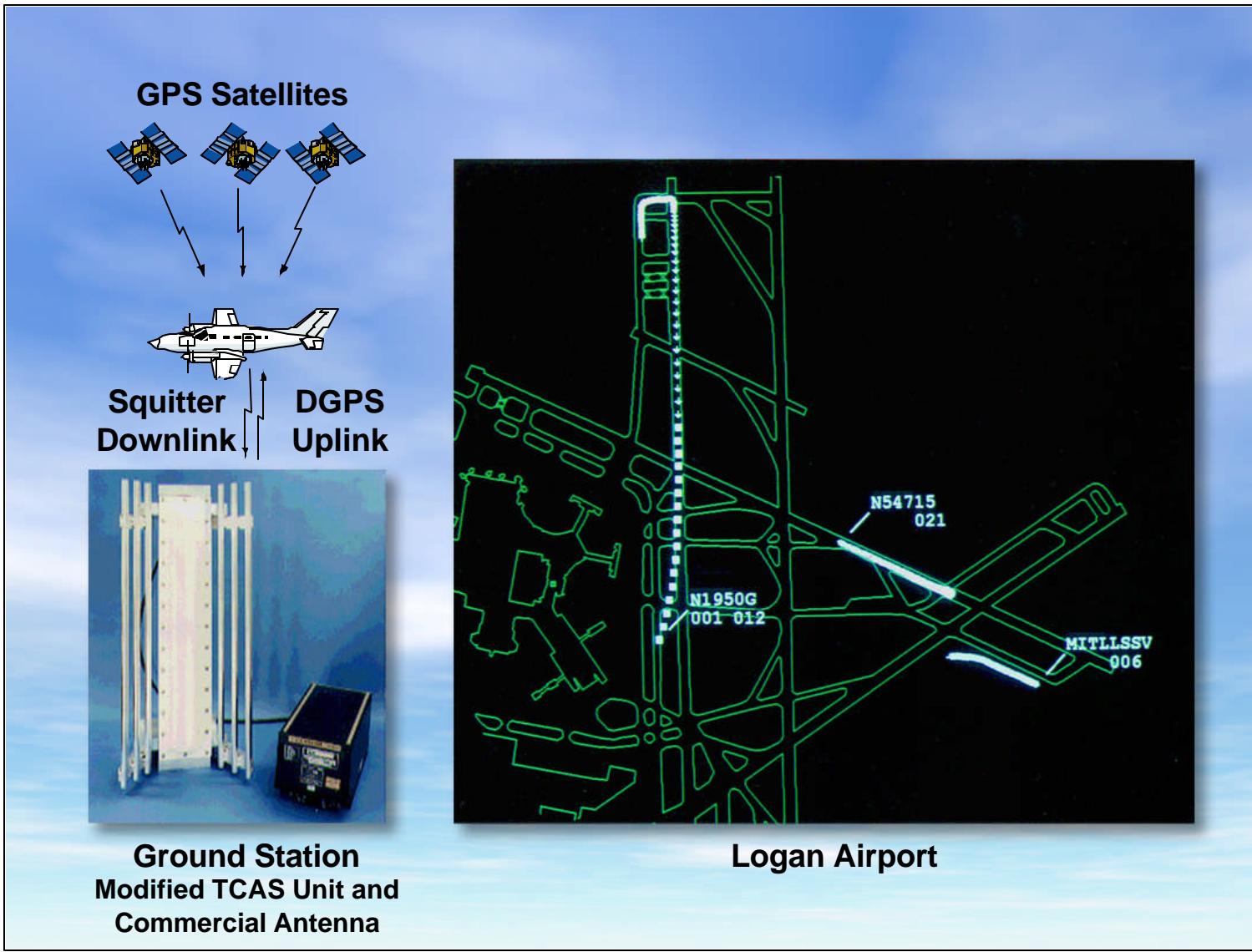


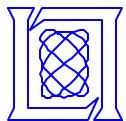
1995 data

MIT Lincoln Laboratory

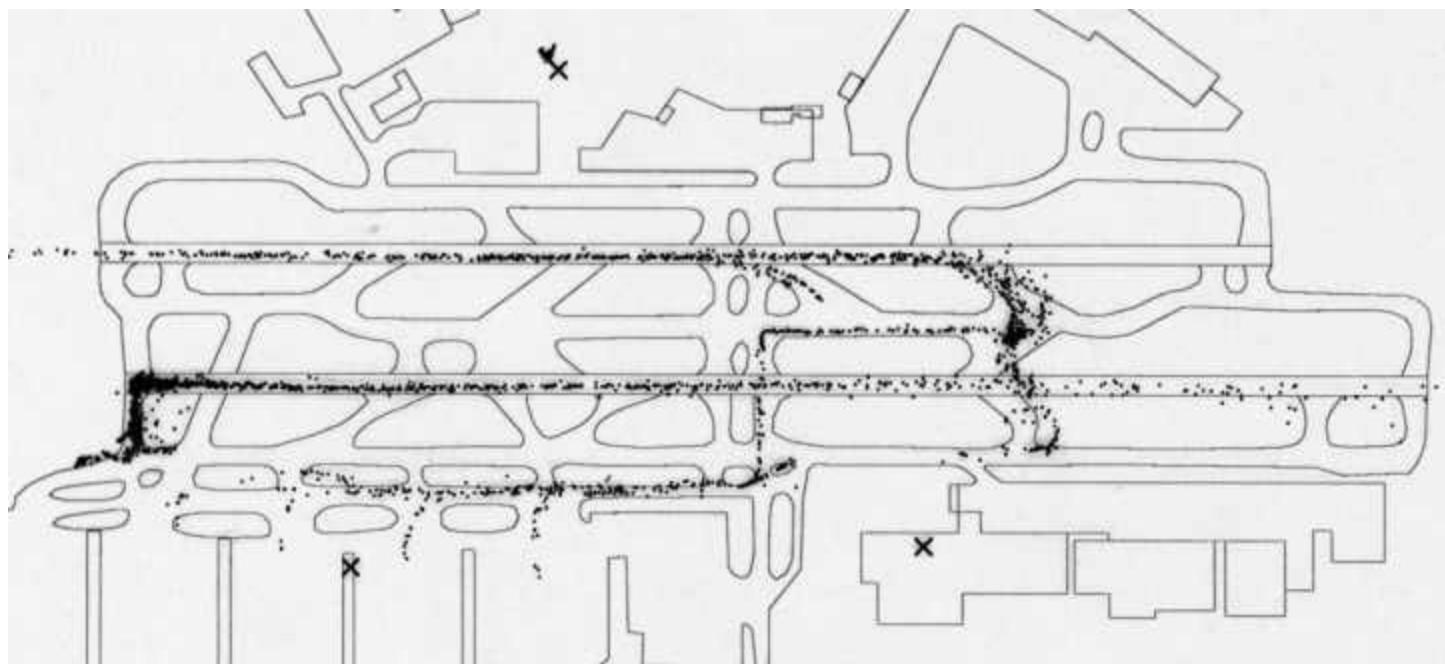


ADS-B at Logan





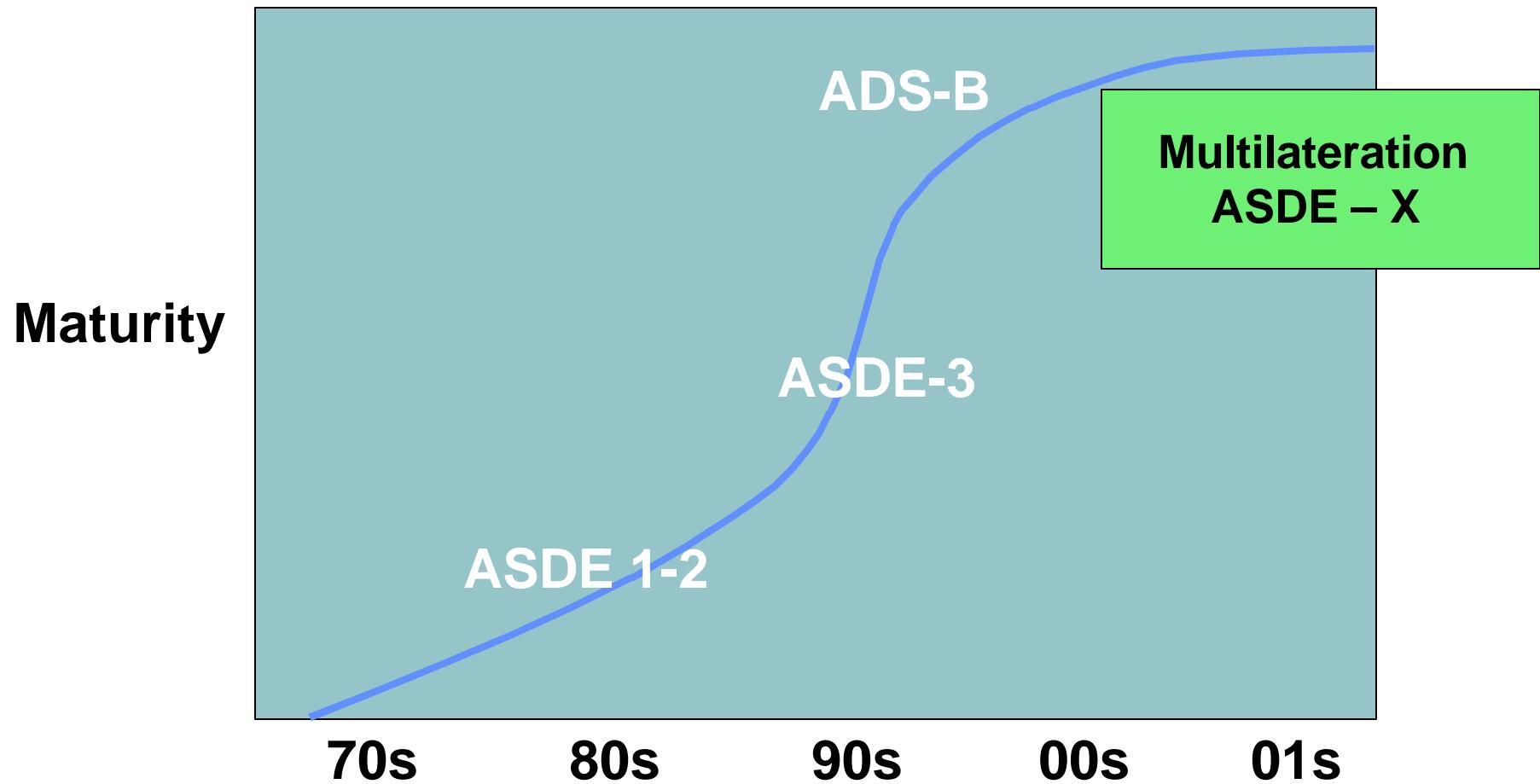
Multilateration at Atlanta

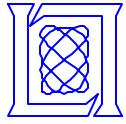


1997 Data



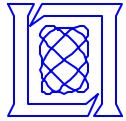
Airport Surface Surveillance Maturity





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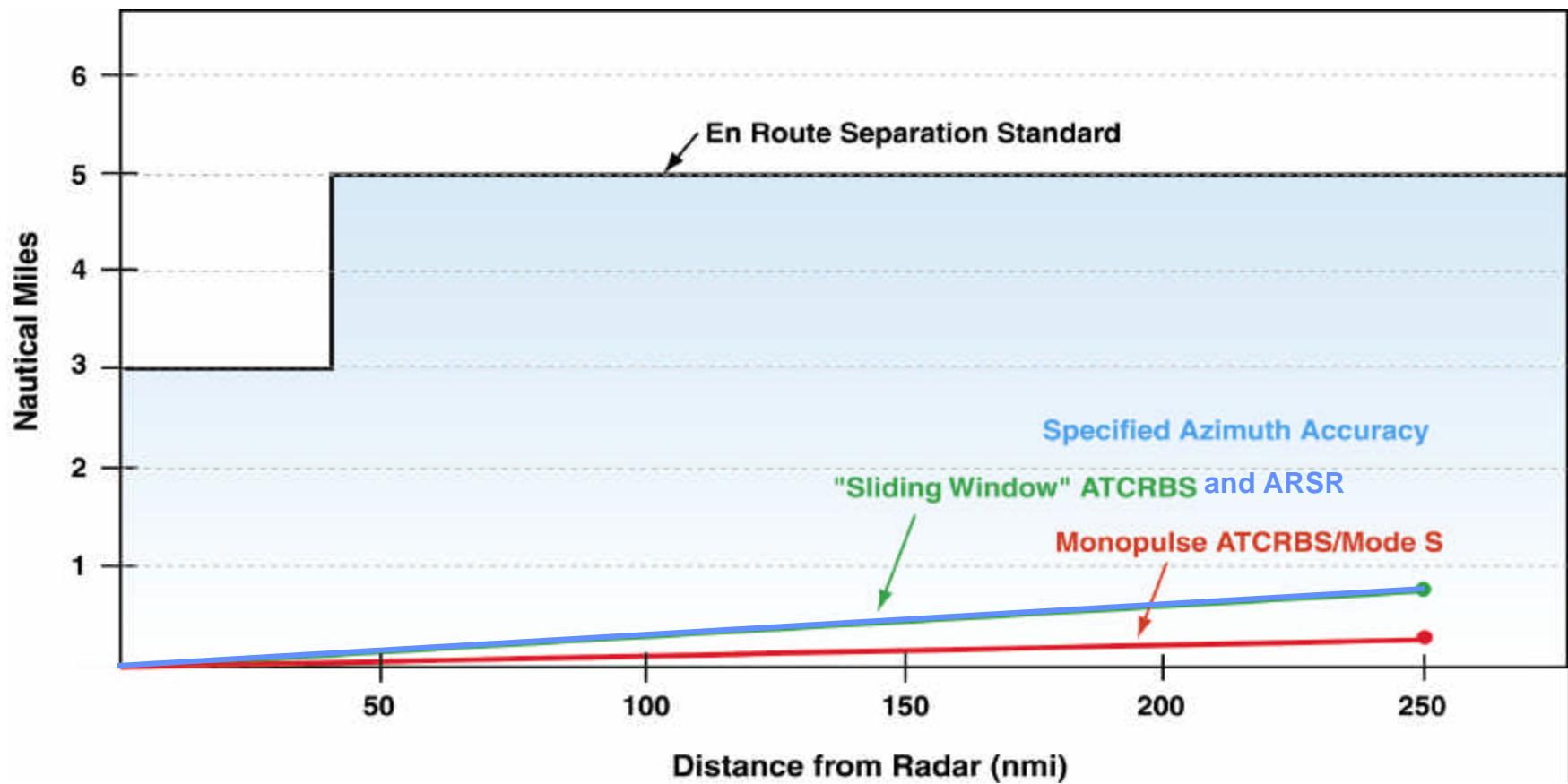


A Key Lesson Learned

**There is no substitute for
comprehensive testing
in realistic field environments!**



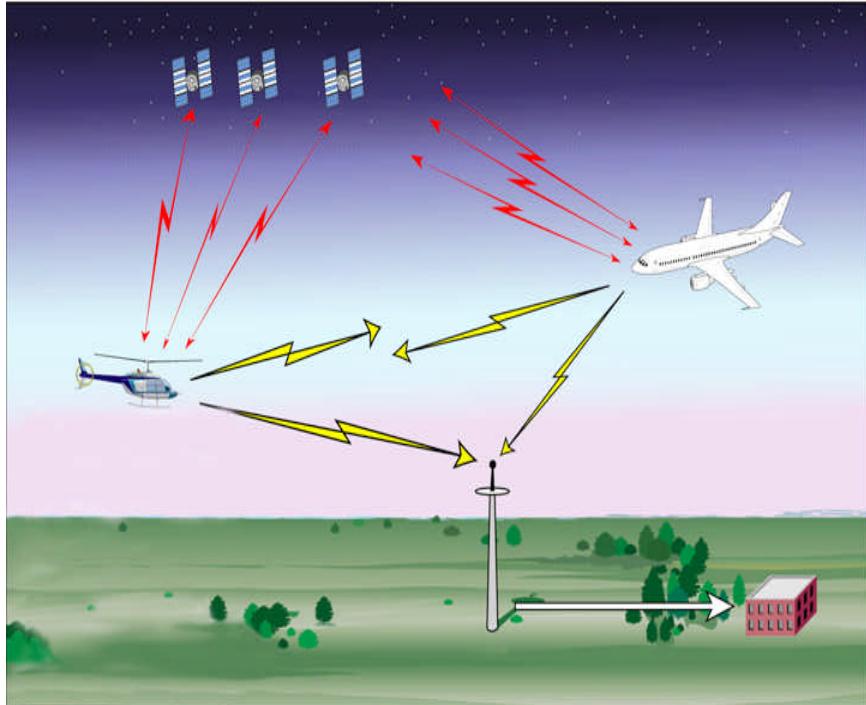
How Much Accuracy Is Needed ?



Surveillance errors – a small fraction of separation standards

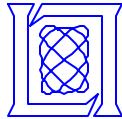


ADS-B



- **Valuable for certain applications**
 - Remote or Challenging Areas
 - Gulf of Mexico
 - Airport Surface
 - Maybe Parallel Approaches
- **But Some Big Claims:**
 - “It will render radar obsolete”
 - “It will enable Free Flight”

The Case for ADS-B is not yet compelling



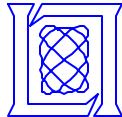
Oceanic Surveillance

- **Motivation**
 - Demand for best weather tracks
 - Traffic Growth in the North Atlantic, Pacific Rim
- **What's Needed**
 - “Enroute Like” Surveillance by ~2020
 - Sensible for non-airline aircraft
- **Initial Systems Engineering Should Start Now !**



Looking Ahead

- A Surveillance Data Network
- Radar Open Systems Architecture



Final Thoughts

- **We have come a long way since WWII !**
- **Primary and Secondary Air Surveillance Systems Are Relatively Mature**
 - **Airport Surface Surveillance Development needs to be completed and applied**
 - **Oceanic Surveillance Needs Attention**
- **Let ADS-B find natural applications**
- **There are no silver bullets in surveillance!**